COMMENTARY

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HOW BEARDED VULTURES (*GYPAETUS BARBATUS*) ACQUIRE THEIR ORANGE COLORATION: A COMMENT ON XIROUCHAKIS (1998)

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Bearded Vultures (*Gypaetus barbatus*) are unique among raptors in that they have cosmetic coloration in their plumage. The typical bright orange coloration of adults is due to iron-oxide particles that coat the otherwise pure white feathers in the head, neck and ventral parts (Cramp and Simmons 1980, del Hoyo et al. 1994). The initial debate on the origin of the pigmentation of Bearded Vultures was settled long ago by conducting chemical and physical analyses of the feathers (Berthold 1967, Brown and Bruton 1991), but one fundamental question remained. Do Bearded Vultures actively stain their feathers by seeking sources of iron oxide, or does the plumage accidentally acquire its rufous color from the rocks where the birds roost or from the water in which they bathe? In other birds where cosmetic colors have been reported from soils, it is possible that the pigments are acquired passively (Kennard 1918). Among waterfowl, for instance, stained individuals are common in species that dig for their food among the iron-rich mud in shallow waters, while those species that are unstained usually forage in deeper waters or in dry fields.

Until recently, it was thought that the adventitious pigmentation of Bearded Vultures was passively acquired from stained rock ledges because no birds had ever been seen bathing in red soils or rust-colored springs. Brown and Bruton (1991) contradicted their own hypothesis of accidental coloring which should have no adaptive advantage and proposed a functional hypothesis, based on camouflage and feather protection against abrasion or mallophaga, to explain the coating of plumage with iron oxides. In a recent letter to this journal, Xirouchakis (1998) provided a detailed account on how a Bearded Vulture seemed to produce red dust for bathing by pecking on an eroded limestone rock (terra rosa), but again contradicted himself concluding that feather coloration is passively acquired.

We believe there is now enough evidence to support the hypothesis that Bearded Vultures stain their plumage deliberately. Particularly imposing is the body of work conducted in Austria by Frey and Roth-Callies (1994). They offered damp soils of different colors and provenances to 33 caged birds of different ages, as well as 12 captive-raised individuals at a release site in the Alps. Except for one blind captive bird that remained pure white, all birds always preferred damp red soils containing iron oxides when they were offered with other mud types. All individuals showed an active coloration behavior consisting of a species-specific bathing display that led to the characteristic rufous coloration. Bathing in damp red soils was a much more elaborate behavior than regular bathing in clean water that is commonly observed in captivity (Frey and Roth-Callies 1994) and in the wild (Brown and Bruton 1991). Water bathing, on the other hand, seems to be a common behavior in most vulture species that often gather to wash and loaf (Mundy et al. 1992).

Baths in red damp soil by Bearded Vultures lasted for up to one hour. First, the birds crouched on the red mud, then spread the damp mud that was adhered in their undersides to their shoulders and upper backs with their beaks and talons. Finally, the head was swung repeatedly between the head and shoulders. This type of behavior has even been filmed for the documentary "The Lammergeier is back," directed by Michel Terrasse. Bathing in red soils seems to be an innate behavior, as young captive birds raised in isolation showed this behavior as soon as they were presented with damp red soils.

Recent observations in the wild, including Xirouchakis's, also demonstrate that the cosmetic coloration of Bearded Vultures is deliberate. An adult Bearded Vulture was observed bathing in a rust-colored spring in the French Pyrenees in 1995 (Caussimont et al. 1995), in what may be the first reported case of a Bearded Vulture coloring itself in the wild. A similar observation has been recorded at a Bearded Vulture breeding territory in the Spanish Pyrenees. In January 1998, one adult Bearded

Vulture was seen landing on the ground, near the bottom of a cliff. It walked toward the cliff bottom and went out of sight, but soon reappeared with its breast wet and dirty. It went there once more, and still moved to a second spot located a few meters away, coming out with its breast soaking wet. When these places were inspected, the first one had a rusty soil dampened by a slight trickle of water, and the second had a small (<1 m^2), transparent pool with iron oxides at the bottom. There were orange splashes in the surrounding snow and some feathers that were collected. We visited this place three more times in the following months (February, April and October) and found new feathers each time, indicating that Bearded Vultures had later returned to bathe. These observations suggest that color intensity, and thus the great individual variation observed in some populations, such as the one in Crete (Xirouchakis 1998), southern Africa (Brown and Bruton 1991) and the population that we are studying in the Spanish Pyrenees, is at least partly related to the frequency of baths and/or chromatic variations that are in different substrates such as in rust-colored springs. Suitable sources of iron oxides for plumage staining may be limiting for Bearded Vultures (Houston et al. 1993), and thus not all individuals in a population would have ready access to color sources, particularly if they are within the defended territories of conspecifics.

Despite many hours of systematic observations, including the tracking of radio-marked birds in southern Africa, the Alps and Pyrenees, the only reported observations of Bearded Vultures bathing to color their feathers are the ones that we mention. As suggested by Houston et al. (1993), coloration of feathers by bathing in wild Bearded Vultures is a very secretive behavior, quite different from the often communal and conspicuous bathing of other vulture species (Mundy et al. 1992). Nevertheless, it is a sophisticated behavior. The next question that needs to be explored is why do Bearded Vultures coat their plumage to such an extent all across their breeding range in Eurasia and Africa. Now that solid evidence of deliberate staining of the feathers in this species is accumulating, it is legitimate to look for an adaptive explanation.

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